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Title:	Next steps in our hydro simulations core and surface, g-modes and p-modes
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NEXT STEPS IN OUR HYDRO SIMULATIONS

CORE AND SURFACE, G-MODES AND P-MODES

Philipp Edelmann

FULLY COMPRESSIBLE SIMULATIONS

Astronomy & Astrophysics manuscript no. igw
May 5, 2020

Fully compressible simulations of waves and core convection in main-sequence stars

L. Horst[1], P. V. F. Edelmann[2,3], R. Andrássy[1], F. K. Röpke[1,4], D. M. Bowman[5], C. Aerts[5,6,7], and R. P. Ratnasingam[2]

Just resubmitted…

SEVEN-LEAGUE HYDRO CODE

- fully compressible Euler equations in 1-, 2-, 3-D
- finite-volume scheme: stable without setting an explicit viscosity
- Cartesian, spherical, or other geometries
- colocated grid (all variables defined at cell centers)
- explicit or implicit time integration
- more detailed microphysics (EoS similar to MESA)

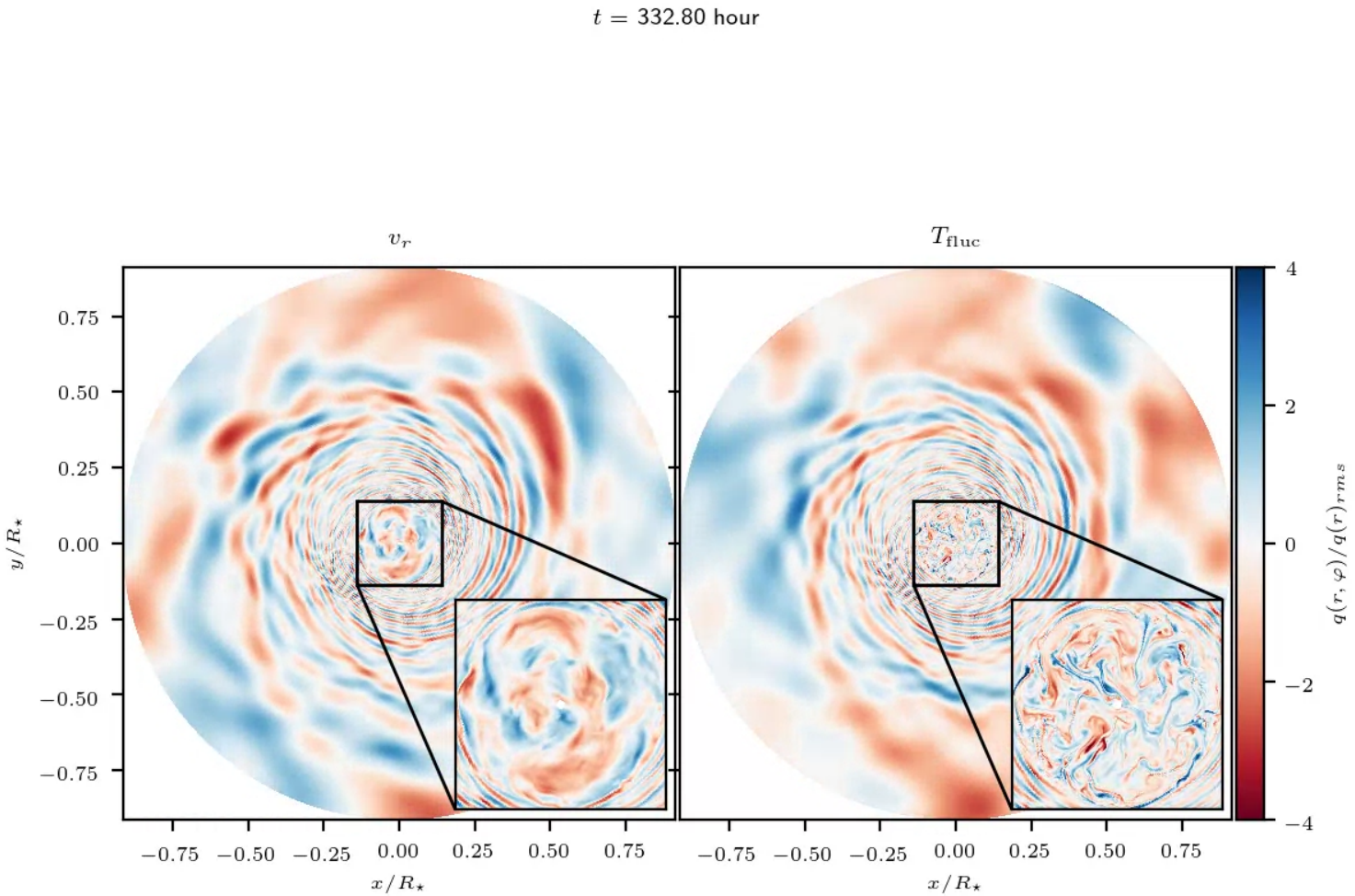
Pro:

- can simulate sound waves
- exactly follows physical conservation laws
- no explicit viscosity needed
- EoS similar to MESA

Con:

- Spherical geometry cut at the pole
- exact amount of numerical viscosity undetermined
- computationally expensive

2D RESULTS FROM HORST+ (2020)



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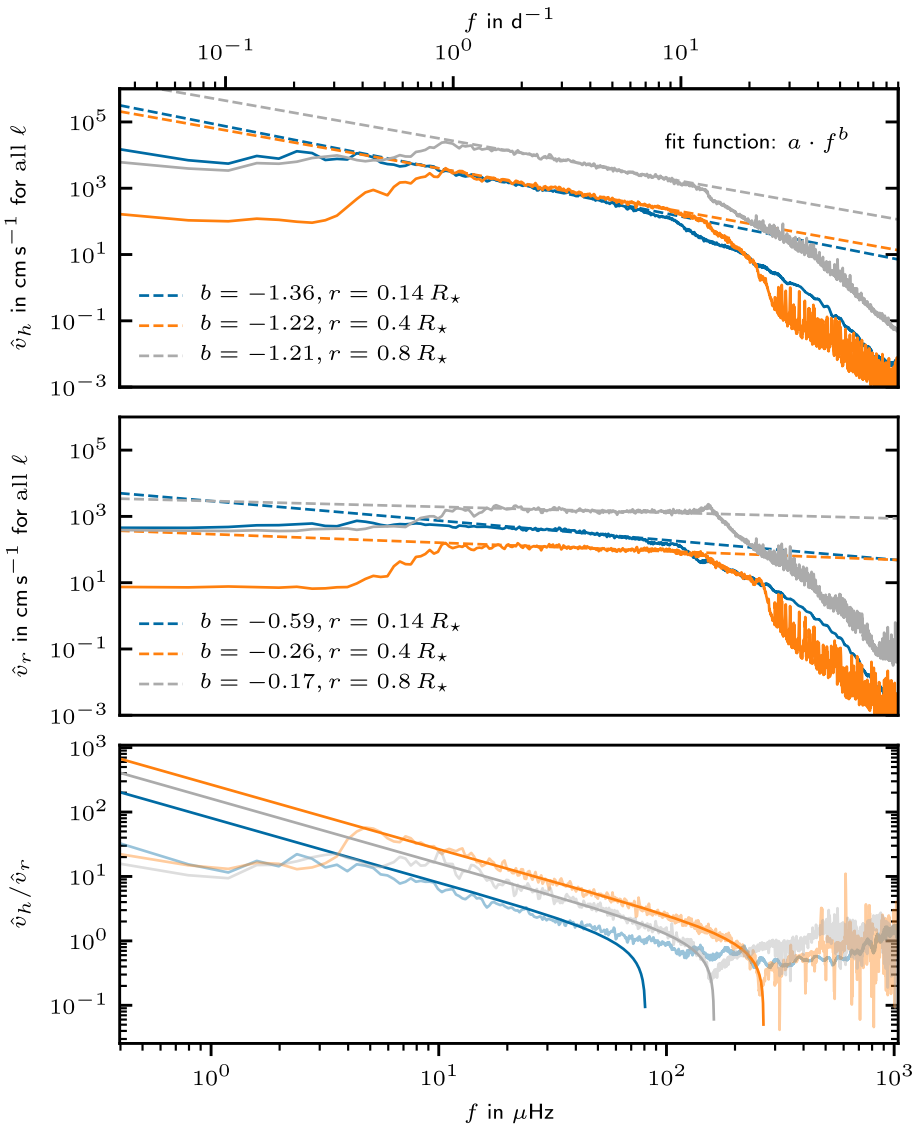
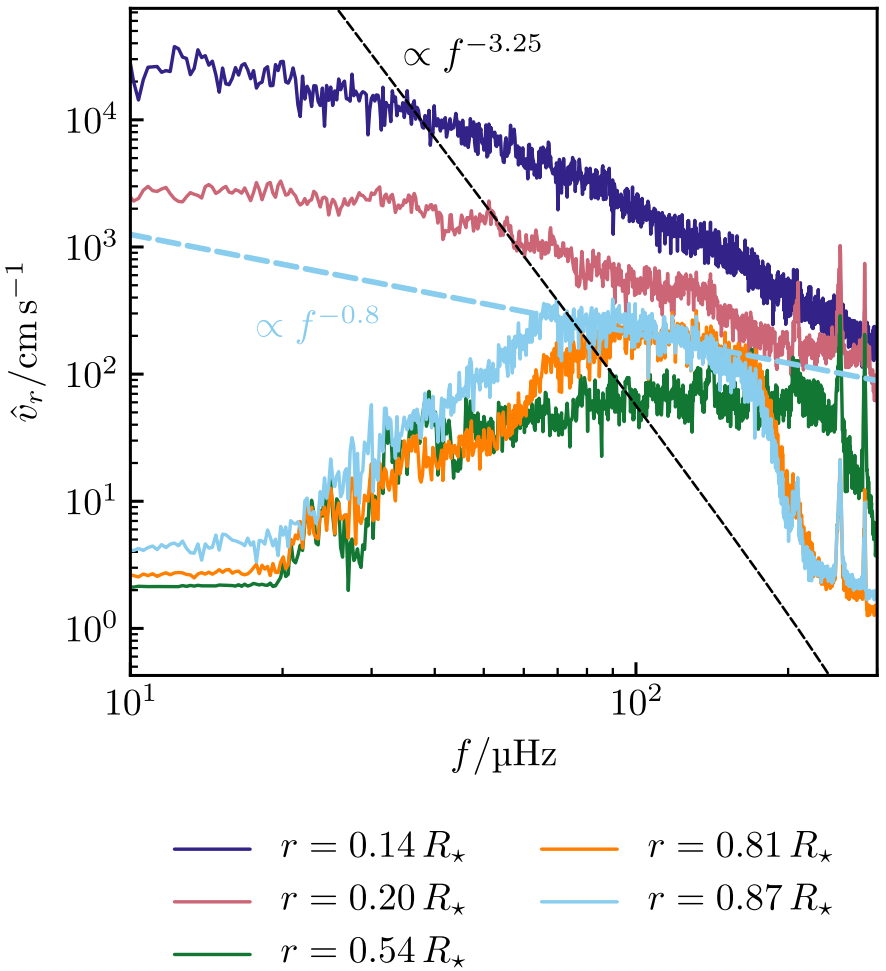
VELOCITY SPECTRA

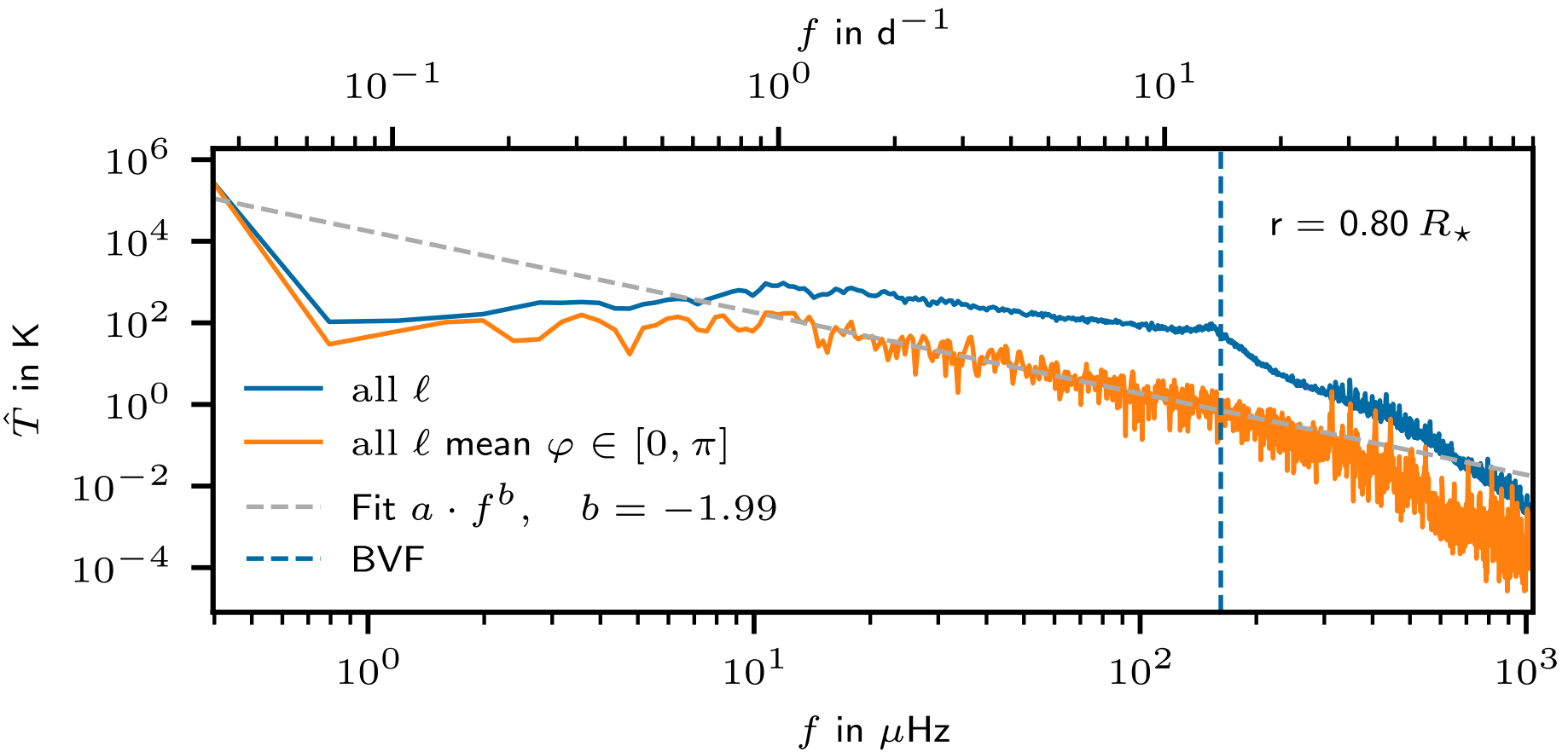


radial velocity from Edelmann+ (2019)

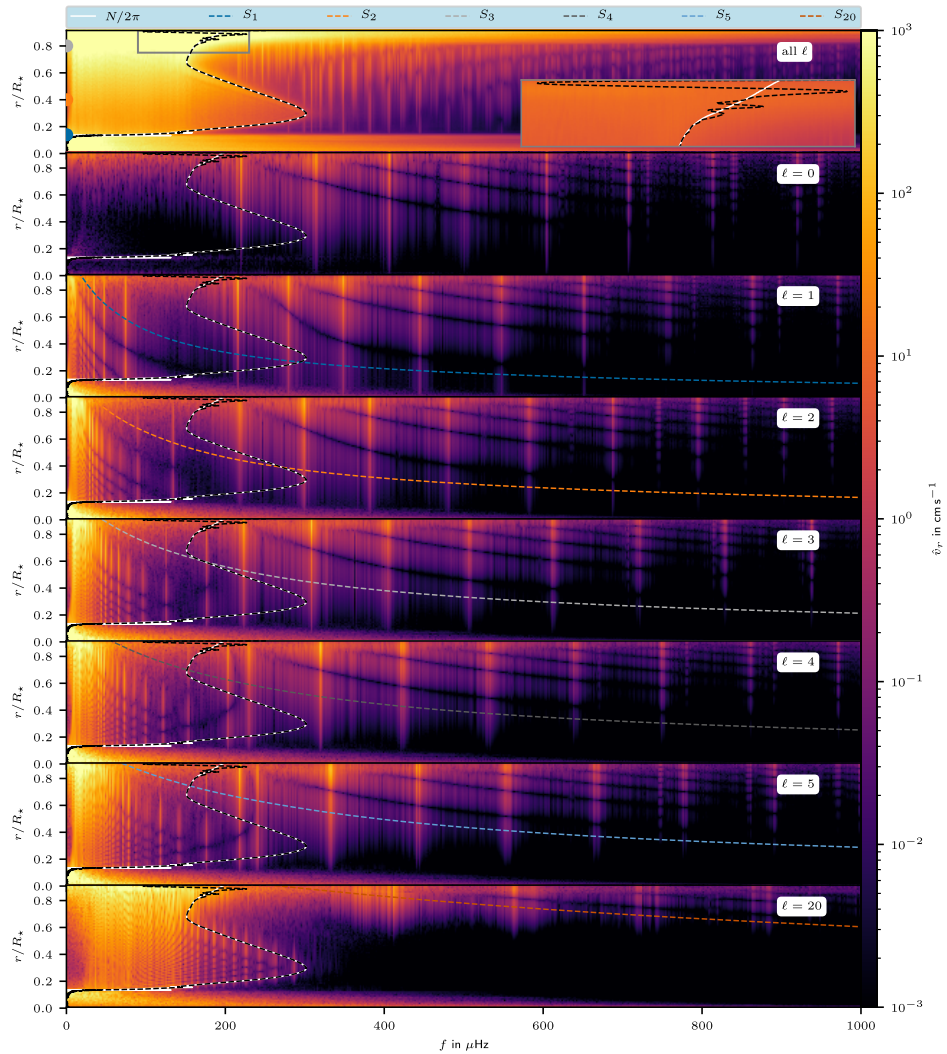


TEMPERATURE

averaged over semicircle to pretend observation
Suggested discussion: How can we do this better?



P-MODES AND G-MODES



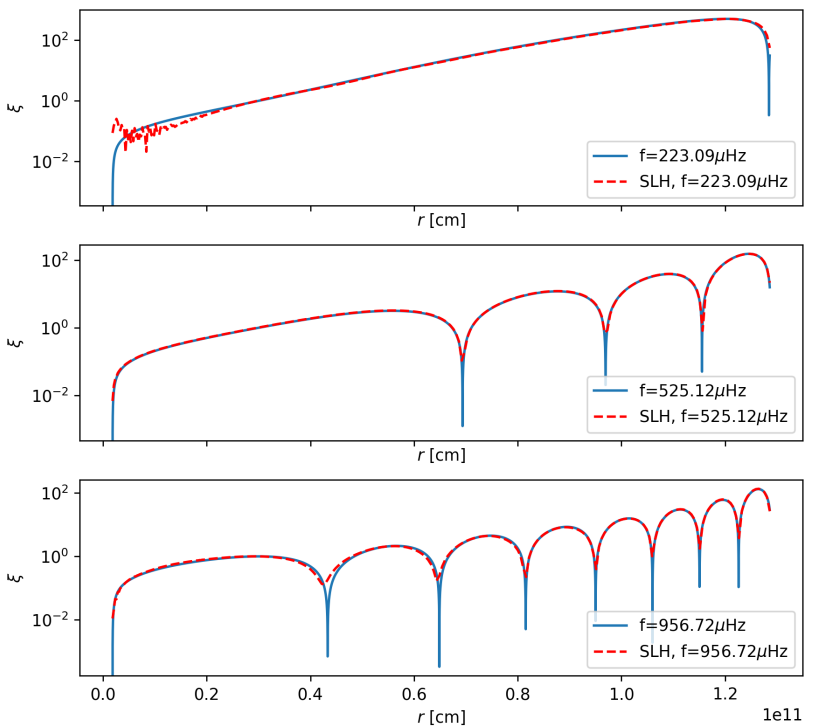
INITIAL 3D WORK

work by Leo & Robert

- initial 3D simulations at ¼ the 2D resolution: 280x90x180
- theoretical comparison with a radial p-mode as a test

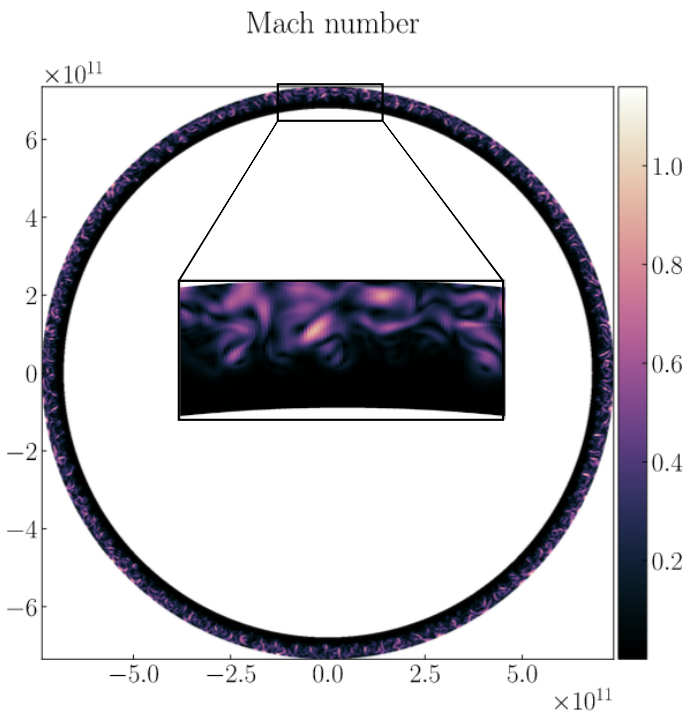
Why not just use GYRE?

- GYRE does not support our hard-wall BCs.
- We did not manage to turn on the Cowling approximation in GYRE. We need it, because we use a static gravitational field in SLH.



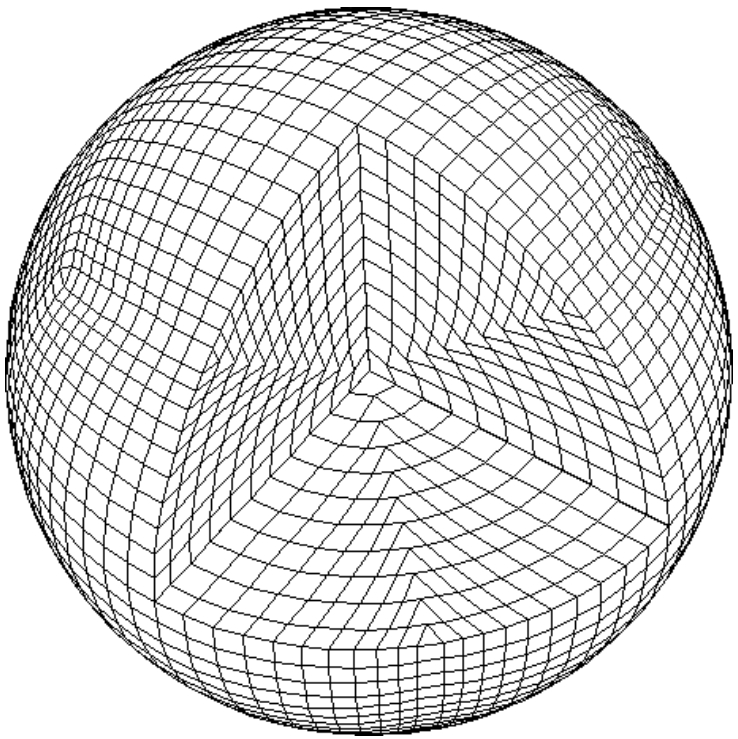
SURFACE CONVECTION SIMULATIONS

state three years ago

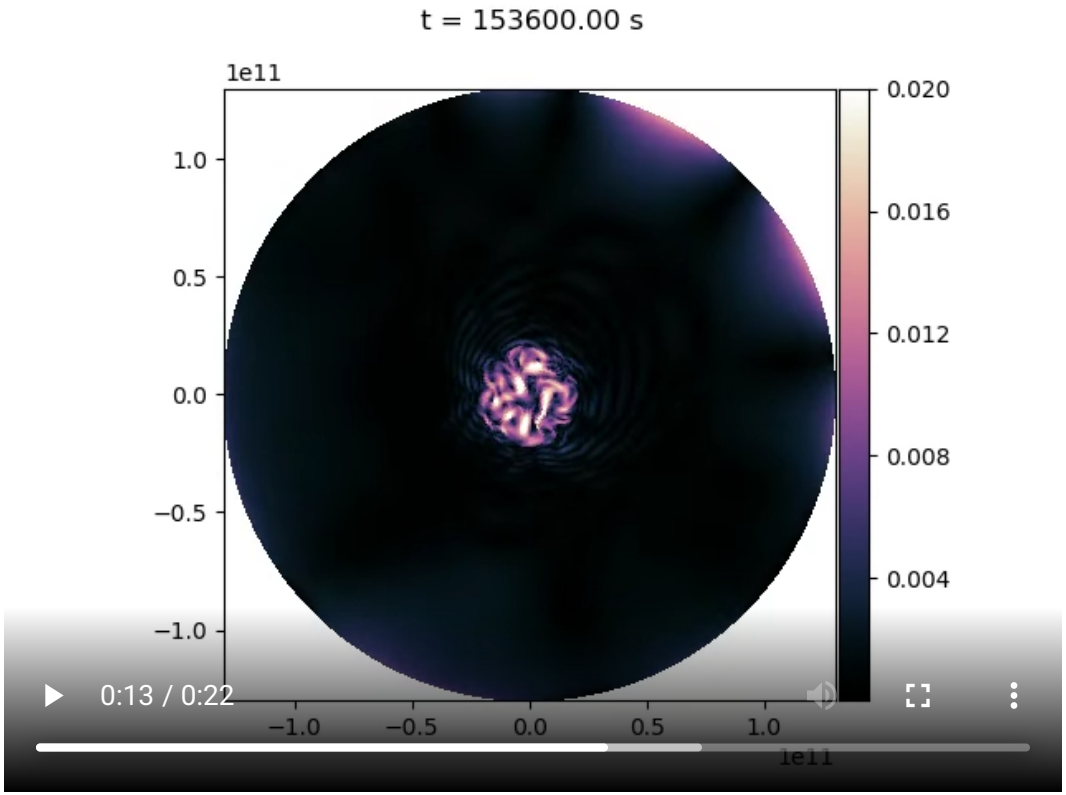


- transonic convection
- SLH was lacking operator splitting to treat radiative diffusion implicitly and hydro explicitly
- This is implemented now!

SIMULATIONS WITHOUT A CUT-OUT CORE



cubed-sphere grid

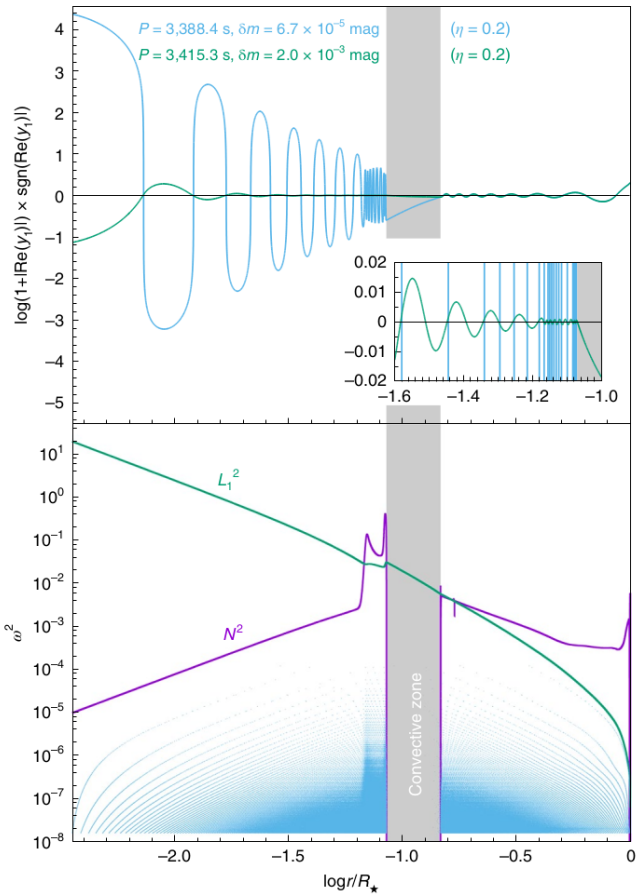


preliminary test by Leo

ASTEROSEISMIC SIGNATURES OF THE HELIUM-CORE FLASH

work by Johann Higl (postdoc@HITS)

- Convective He-burning shell during Sub-He-Flash of SdB star
- SLH simulations (likely 2D for now)
- from CZ up to ~85% of star's radius (95% might also be possible depending on resources)
- stiff convective boundary



Bertolami+ (2020)